View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by The University of Utah: J. Willard Marriott Digital Library

Journal of Physical Activity and Health, 2008, 5, 882-893
© 2008 Human Kinetics, Inc.

Using Accelerometer Feedback to Identify Walking Destinations, Activity Overestimates, and Stealth Exercise in Obese and Nonobese Individuals

Barbara B. Brown and Carol M. Werner

Background: Accelerometer output feedback might enable assessment of recall biases for moderate bouts by obese and nonobese individuals; accelerometry might also help residents recall destinations for moderate-intensity walking bouts. ***Methods:*** Adult residents' 1-week accelerometer-measured physical activity and obesity status were measured before and after a new rail stop opened (n = 51 Time 1; n = 47 Time 2). Participants recalled the week's walking bouts, described them as brisk (moderate) or not, and reported a rail stop destination or not. ***Results:*** At the end of the week, we provided accelerometry output to residents as a prompt. Recall of activity intensity was accurate for about 60% of bouts. Nonobese participants had more moderate bouts and more "stealth exercise" —moderate bouts recalled as not brisk—than did obese individuals. Obese participants had more overestimates—recalling light bouts as brisk walks—than did nonobese individuals. Compared with unprompted recall, accelerometry-prompted recalls allowed residents to describe where significantly more moderate bouts of activity occurred. ***Conclusion:*** Coupling accelerometry feedback with self-report improves research by measuring the duration, intensity, and destination of walking bouts. Recall errors and different patterns of errors by obese and nonobese individuals underscore the importance of validation by accelerometry.

Keywords: environment, physical activity assessment, METs, community-based research

Can individuals recall when their walking bouts are long enough and brisk enough to constitute healthy bouts? Can obese individuals, who suffer great health risks, recall walking bouts as accurately as others? Can participants recall particular walking destinations, and do these destinations account for any moderate physical activity bouts? As physical activity studies move from the more controlled environment of the gym or laboratory to everyday community settings, researchers have begun to ask how particular physical features relate to walking

Brown is with the Dept of Family and Consumer Studies, and Werner the Dept of Psychology, University of Utah, Salt Lake City, UT 84112.

and whether particular groups of individuals are more likely to take advantage of them. We used self-report with accelerometry prompting to better understand brisk walking bouts, especially walking to a neighborhood rail transit stop. We compared obese and nonobese individuals and asked whether they differ in walking bouts overall and to transit. Furthermore, because obese individuals are known to overestimate energy expenditure, we compared obese and nonobese individuals' accuracy of self-reported intensities of walking bouts.

Healthy physical activity levels, according to CDC-ACSM guidelines, involve "30 or more minutes of moderate intensity physical activity on most, and preferably all, days—either in a single session or 'accumulated' in multiple bouts, each lasting at least 8–10 minutes."[1(p.23)] Moderate-intensity bouts achieve 3 to 6 metabolic units (METs) of effort,[2] which can be measured with accelerometers. Under controlled conditions, when researchers tell participants to walk briskly, they generally achieve the moderate-intensity MET threshold.[3,4] However, it is not clear whether community-dwelling residents walk at a brisk, moderate pace in daily life, whether they can accurately recall their brisk walking bouts for researchers, and whether they can recall walks to particular community destinations such as rail stops.

Although research shows rail users report walking more than nonusers,[5,6] few studies have asked whether walks to light rail stops can be brisk walking bouts. A well-known compendium of physical activity intensities lists the average MET level associated with walks to bus stops as only 2.5 METs, halfway between the 2.0 MET 2-mph stroll and the 3.0 MET moderate-intensity walk.[7] Thus, it is important to measure whether walks to rail transit ever achieve moderate intensity and whether obese and nonobese individuals take advantage of these daily opportunities for healthy walking. When active travel involves the use of a rail stop, both individual and community health may benefit. Rail use is healthier for the environment than car dependence because it requires less infrastructure and causes less pollution. Walks to transit can be socially and economically healthy as well, by supporting a visible social presence, local social encounters, and patronage of transit-area shops and services, all without the expense of the private car. Thus, light rail stops are one of many community design features that merit research on their ability to support many facets of community health; we focused on walks to rail stops, although other researchers may adapt the methodology to assess walking to other destinations.

An important limitation in understanding how community design features support physical activity is that the best objective measures of free-living moderate activity—via accelerometry—have not yet been linked to particular community features such as transit stops. Instead, walks to transit are often identified through travel diaries that ask participants to list where they are and what they are doing throughout the day.[5] Such measures impose substantial participant burden, do not assess physical activity intensity, and do not connect accelerometer intensity levels with use of community features such as transit stops. Therefore, researchers are calling for better measures of transportation-related physical activity.[8]

A less burdensome and more activity-specific measure would be to ask participants how many times they walked to a transit stop in brisk bouts of 8 or more minutes over a period of time such as the past week. However, this might yield incomplete recalls and inaccurate judgments of physical activity intensity. Indeed, recall of moderate activity is not as good as recall of vigorous activities, according to a review of 6 studies of adults.[9] This difference could occur because moderate activity lacks built-in memory aids, such as scheduled times or the vividness of physically demanding exertion.[10] The current research asks whether we can improve reports of walks to transit by prompting participants with the day, time, and duration of moderate activity bouts from the accelerometry record.

Physical activity recall accuracy has also been found to vary by body size, with overestimates more likely for those with excess weight.[11–14] Given the health risks of obesity, it is important to ask whether obese individuals' biased recall for total physical activity is also exhibited in their recall of moderate bouts of activity. The current study examined whether community residents can accurately recall moderate-intensity bouts of activity, whether recall accuracy varies by body size, how prompting of recall of moderate activity bouts via the accelerometry record might enhance recall, and whether moderate activity bouts include walks to rail stops.

Methods

Setting

The study area was a neighborhood identified by Salt Lake City for redevelopment efforts. The neighborhood had multiple industrial land uses, commercial warehouses, subsidized apartment complexes, market-rate multifamily dwellings, and small post-World War II single-family detached homes. The residential areas had gridded street patterns and tree-lined sidewalks but few walkable destinations beyond convenience stores.

New Rail Stop

Residences within a direct half mile (804 m as the crow flies) of a planned light rail transit stop were targeted because a half mile is generally considered the maximum walking distance to transit.[15,16] The new light rail stop was constructed between 2 existing stops, bringing rail service closer to the neighborhood (Time 1 mean distance from residence to closest rail stop = 743 m, SD = 357 m; Time 2 mean = 344 m, SD = 208). The rail stop had no parking facilities, and local riders typically walked to the stop. As reported elsewhere, despite long walking distances to the nearest rail stop before the construction of the neighborhood stop, half the residents at Time 1 reported they had ridden rail within the last 2 weeks.[17] At Time 2, after the new stop brought rail service closer, 18.75% more residents reported riding rail in the last 2 weeks. For the current report, we focus on how we used data supplied by the accelerometer program to prompt residents to identify previously unrecalled moderate bouts of activity to rail stops and elsewhere.

Participants

All adult residents in the sampling area were targeted, and of the 215 individuals contacted, 51 at Time 1 and 47 of the same residents at Time 2 provided accelerometer data (at Time 2, 51 provided survey data but 4 did not want the inconvenience of wearing the accelerometer). Although 102 residents had been recruited during Time 1, many had moved by Time 2 (dropouts did not differ from the panel sample in terms of physical activity or demographic profiles, for details, see[17]), so subsequent analyses focus on the panel sample. The panel sample was 47% female, 79% white, 16% Hispanic, and averaged 41 years of age (using Time 1 data). Children were present in the homes of 35% of residents, 32% were married, and 42% were single (the remaining were divorced, widowed, or separated). Income averaged $24,000 for the household, and 55% lived in single-family detached housing.

Accelerometer and Obesity Measures

Accelerometry data were collected with Actilife 1.0.34 software for MTI model GT1M accelerometers (ActiGraph, Fort Walton Beach, FL, 2005) set to record 1-minute epochs. MTI accelerometers have been shown to be reliable.[18] To assure reliability, participants' height (without shoes) and weight measures were taken twice each time using Tanita scales and Seca 214 portable stadiometers; measures were averaged if there was a discrepancy. Obesity was measured as a body mass index (BMI) equal to or greater than 30 kg/m^2.

Procedures and Walk Recall Measures

University of Utah Institutional Review Board approval was obtained before distributing letters to residents alerting them to a "survey of people's feelings about their homes and communities." Research assistants followed up with door-to-door recruitment visits to explain the study and the accelerometer. Residents received $20.00 for completing each phase of the study. To equate for good walking weather, residents wore hip-mounted accelerometers for 1 week during summer of 2005 (Time 1: late June to early September) and 1 week during summer of 2006 (Time 2: May through July). Meetings lasted about 45 minutes at the beginning and about 35 minutes at the end of the week.

At the end of each week of accelerometry data collection, a researcher met with each participant. Participants completed surveys, which included a question about the total number of rail rides in the past 2 weeks (called "2-week self-reports," a question adapted from one with predictive validity in past research[19]). They also completed a walking-bout recall survey on which participants reported walks to a rail stop and other walking trips in the last week that lasted at least 8 minutes in duration, starting the previous day and working back in time (called "unprompted recall"). Respondents designated whether each recalled walk was brisk and whether a rail stop was a destination. Meanwhile, the researcher connected the accelerometer to a laptop computer where software quickly produced a minute-by-minute Excel table showing physical activity intensity by day and time. The researcher highlighted moderate bouts of activity on the Excel table. Moderate activity was defined as least 1952 counts per minute.[20] To be considered long enough to meet the CDC-ACSM standard, moderate bouts required the accumulation of 8 or more moderate minutes with no interruptions lasting more than 2 minutes; this definition allowed for short interruptions, such as crossing an intersection. The research assistant could then compare the highlighted accelerometry moderate bouts with the participant's self-reported brisk walking bouts to see if there were additional moderate bouts participants had not recalled. Respondents were shown the exact day and time of moderate-intensity bouts they had overlooked and filled out a survey that asked if the moderate activity involved a brisk walk and whether it was to a rail stop. Thus, each participant supplied first the unprompted and then the prompted recall of moderate activity bouts. At Time 1, participants had not been told at the beginning of the week that they would be asked to recall brisk walks at the end of the week; at Time 2 they were not explicitly told they would do the same recall, but the recall task might have been anticipated.

Data Analyses

To establish the stability and construct validity of the recalled bout measures, recall of walking bouts from Time 1 and Time 2 are correlated, and recalls to rail stops are correlated with the 2-week self-reports of all rail rides, a measure used in travel research.[19] The ability of prompting to add significantly to the number of bouts recalled is assessed with t tests that compare prompted and unprompted recalls for all bouts and for bouts to a rail stop. Then obese and nonobese residents are compared for moderate physical activity bouts, assessed by accelerometer and then by recall, using t tests. Patterns of recall accuracy (comparing recall with accelerometer data) are described and t tests used to contrast obese and nonobese participants. Significance levels were set at $P < .05$, and data were processed with SPSS 14.0.2 software (SPSS, Chicago, IL, 2006).

Results

Reliability and Validity of Prompted Recalls to Transit

Recalls of walking bouts to the transit stop are tested in 2 ways: in terms of stability of measures from year 1 to year 2 and in relation to the 2-week self-report of number of rail rides. Year 1 unprompted ($r = .59$) and prompted ($r = .56$) recalls of moderate bouts were related to their year 2 counterparts. Convergent validity is supported by evidence of relationships between the 2-week self-report of total rail rides and the accelerometer recalls of walking bouts to the rail stop (ie, of any intensity and prompted or unprompted): $r = .57$ at Time 1 and $r = .73$ at Time 2. The 2-week survey measure was also related to both unprompted ($r = .67$ and .61, Times 1 and 2, respectively) and prompted ($r = .65$ and .71) recall of moderate-intensity bouts to rail transit. Thus, memory for walking bouts to rail stops and improvement via prompting are fairly stable over a year and related to preexisting measures of rail ridership.[19]

Accelerometry Prompting of Recalls

To determine whether accelerometer prompting allows participants to recall significantly more moderate bouts to any destination than unprompted recall alone, t tests were computed (contrasting prompted plus unprompted bouts with unprompted bouts alone). Figure 1 and Table 1 show that accelerometer evidence of moderate activity added significantly to the total number of moderate bouts the participant could recall and describe, at both Time 1 (t_{50} = –4.83, P < .001) and Time 2 (t_{46} = –3.62, P = .001). Looking exclusively at walking bouts to transit stations, accelerometer evidence of moderate bouts also added significantly to participants' ability to recall moderate bouts to transit stations, at both Time 1 (t_{50} = –2.61, P = .012) and Time 2 (t_{46} = –2.14, P = .038). At Time 1, residents recalled an average of 0.31 (SD = 0.88) moderate bouts to rails stops, and prompting brought that average up to 0.63 (SD = 1.61); at Time 2, the unprompted recall averaged 0.40 (SD = 1.08), and prompting brought that up to 0.60 (SD = 1.54) moderate bouts to rail stops.

Obesity and Moderate Activity Bouts

Consistent with what one would expect, obese (n = 18 Time 1 and n = 16 Time 2) and nonobese (n = 33 Time 1 and n = 31 Time 2) participants had different amounts of accelerometry-confirmed moderate bouts (both groups wore accelerometers for a similar number of hours). As shown in Figure 2, nonobese individuals had about 6.7 accelerometer-confirmed moderate bouts in the Time 1 week and 7.6 in the Time 2 week, whereas obese individuals had 1.6 and 1.5 moderate bouts, respectively (nonobese versus obese Time 1: t_{49} = 3.04, P = .004; Time 2: t_{45} = 2.49, P = .017). However, self-reported moderate bouts did not differ between groups, with means ranging from 2.6 to 3.6, demonstrating the superior validity of accelerometer reports. Looking exclusively at walking bouts to rail stops, compared with obese individuals, nonobese individuals reported more total rail walk bouts (Time 1: mean = 1.48, SD = 2.49 versus mean = 0.61, SD = 1.58; Time 2: mean = 1.42, SD = 2.53 versus mean = 1.19, SD = 2.61) and more accelerometer-confirmed moderate rail walk bouts (Time 1: mean = 0.82, SD = 1.79 versus mean = 0.28, SD = 1.18; Time 2: mean = 0.65, SD = 1.56 versus mean = 0.50, SD = 1.55). However, despite large differences across the means for nonobese compared with

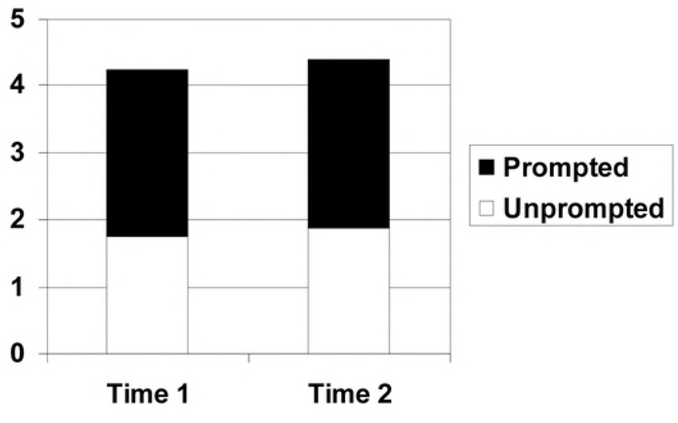

Figure 1 — Unprompted and accelerometer-prompted recalls of moderate activity bouts.

Table 1 Number of Moderate Bouts by Recall Method

	Time 1		Time 2	
Type of moderate bouts	**Mean**	**SD**	**Mean**	**SD**
Unprompted recall	1.75	2.60	1.89	2.33
Accelerometer-prompted recall	2.49	3.68	2.49	4.72

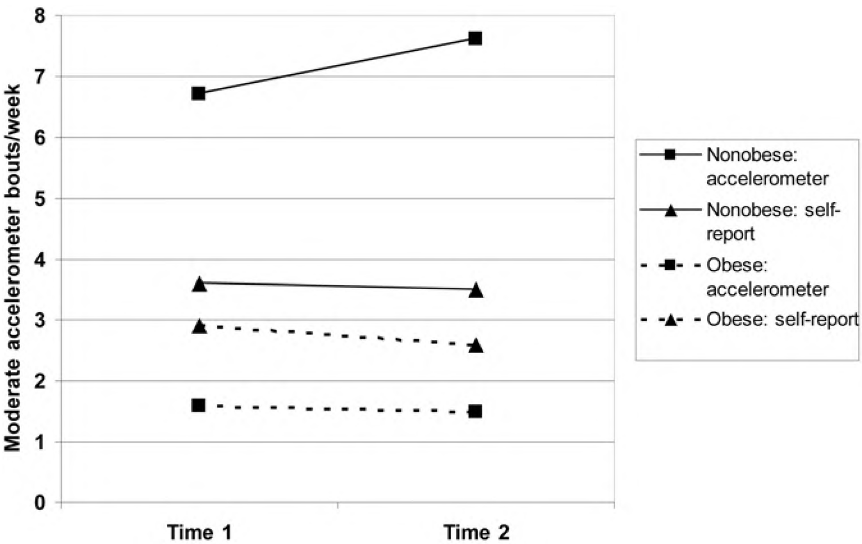

Figure 2 — Self-reported (unprompted and prompted) brisk bouts versus accelerometer-verified moderate bouts of activity for obese and nonobese individuals.

obese individuals' walks to rail stops, the variability of these means is substantial, and the *t* tests are nonsignificant (all $P > .18$).

Walking-Bout Recall Accuracy and Error Patterns

To examine recall patterns, we calculated the proportion of bouts recalled accurately and inaccurately for each participant, thereby controlling for different numbers of bouts. Table 2 shows the 4 categories of agreement between accelerometry and self-report for moderate bouts of activity during the participant's unprompted recall period when they were asked about all 8 or more minute walking bouts and whether they were brisk or not. By adding the top rows that show agreement (regarding light and moderate activity, respectively), results show that overall, about 66% of the Time 1–recalled bouts and 57% of the Time 2–recalled bouts were described in a manner consistent with accelerometer readings, indicating respondents were in error approximately 40% of the time. The most common lack of concordance was an overestimate—a walk recalled as brisk by the participant but which failed to reach the moderate activity accelerometer threshold (as shown

Table 2 Activity-Bout Recall Patterns by Total, Nonobese, and Obese Participants (Proportions): Contrasting Self-Reports With Accelerometer Measures of Intensity

	Total Mean (SD)	Nonobese Mean (SD)	Obese Mean (SD)	*t*
Time 1 (n = 51)				
light-agree	.53 (.41)	.49 (.40)	.61 (.42)	–1.00
moderate-agree	.14 (.26)	.16 (.28)	.09 (.19)	.95
overestimate	.20 (.31)	.16 (.27)	.28 (.36)	–1.35
stealth exercise	.13 (.25)	.19 (.29)	.02 (.10)	2.36[a]
Time 2 (n = 47)				
light-agree	.41 (.38)	.41 (.37)	.41 (.41)	–.10
moderate-agree	.14 (.24)	.17 (.26)	.07 (.19)	1.27
overestimate	.23 (.33)	.16 (.24)	.35 (.44)	–1.97[a]
stealth exercise	.16 (.29)	.22 (.33)	.03 (.09)	2.19[a]

Note. "Agree" refers to agreement between self-reported and accelerometer measures of activity intensity. The data combine prompted and unprompted recalls.

[a] $P < .05$.

in the rows labeled "overestimate" in Table 2, Times 1 and 2). Another lack of concordance was "stealth exercise"—a walk recalled as "not brisk" but which was moderately active according to the accelerometer (as shown in the rows labeled "stealth" in Table 2).

The patterns of recall errors varied by body size. Overall, for 48% to 70% of the bouts, obese and nonobese individuals can accurately label the intensity of their unprompted bouts of activity (as shown by adding the Table 2 rows that indicate agreement between self-report and accelerometer measures). However, as Table 2 shows, obese individuals are more likely to overestimate the intensity of their bouts, a difference that approaches significance at Time 2 ($t_{45} = -1.97$, $P = .055$). In contrast, nonobese individuals are more likely to attain bouts of "stealth exercise," which are moderate activity bouts that they do not recall as moderate; this difference was significant at both Time 1 and Time 2 ($t_{49} = 2.36$, $P < .02$; $t_{45} = 2.19$, $P < .04$).

Discussion

Overall, participants accurately gauged the intensity (moderate or less than moderate) of about 60% of the bouts of activity according to accelerometer verifications. For researchers, the 40% recall error rate underscores the importance of using accelerometry to measure the intensity of physical activity associated with walking bouts among community members.

Nonobese individuals were more likely to underestimate the intensity of their moderate activity bouts, achieving stealth exercise bouts. Although not recognized in past research, this type of error is intriguing for health researchers because it suggests that healthy exercise can be a simple byproduct of daily routines, increasing the chances of active living becoming habitual. Furthermore, if the activity involved in stealth exercise is so unremarkable as to be unmemorable, stealth bouts might be easy for nonobese participants to achieve and, potentially, to make habitual. Perhaps stealth walks are more likely to be experienced when participants are not attending to the briskness of the walk but are attending to other qualities of the activity, such as the scenery or their anticipated destination. If so, communities might be deliberately designed to attract more bouts of moderate stealth exercise, without requiring special motivation or commitment to exercise by residents. Although this study suggests that obese individuals might not experience many stealth bouts, stealth exercise opportunities designed for nonobese individuals might serve as an obesity-prevention tool.

Many community pathways and destinations are believed to attract and support physical activity, such as transit stops,[19] pedestrian pathways and trails,[21] neighborhood parks and recreation centers,[22] walkable routes to school or work,[23] and even dog walks.[24] However, it is difficult to assess use of these facilities or to know if they generate healthy bouts of activity, given the limitations of self-report and the need to determine whether physical activities are long and vigorous enough to meet active-living health goals. Our combination of accelerometry and prompted recall could be useful to researchers who study these other community destinations and pathways as well. We were able to identify more moderate bouts of activity related to walks to a rail stop than we would have without the accelerometer prompting technique. Researchers could use the same prompting technique to identify other bouts of interest.

Walking bouts show particular promise for community-based physical activity. Past research demonstrates that walking is the most popular physical activity[25] and the one most used by those who meet the CDC-ACSM standard.[26] Importantly, simple walking can be done fast enough and last long enough to become moderate activity bouts,[27] especially for less fit individuals who could benefit most from moderate-intensity walking.[28] Individuals might be able to adopt everyday walking routines that are brisk enough and long enough in duration to confer health benefits. Thus, walking is an activity that is appropriate for community-wide promotion efforts and design interventions.

Consistent with past research on total activity levels, obese individuals had fewer bouts of moderate activity. Compared with nonobese individuals, obese individuals were also more likely to recall bouts of activity as brisk when they were in fact light according to accelerometer readings. Past research has not examined accuracy of recall for bouts of walking among obese and nonobese individuals, but studies have identified similar error patterns for recall of total amounts of activity using doubly labeled water. In postmenopausal women enrolled for 24 weeks in a diet study, overestimates of physical activity were found among overweight women but were most likely among the 18 obese women.[13] Before engaging in an intense dieting regimen, 41 overweight women overestimated their physical activity compared with nonoverweight controls.[14] In other research, there was a (nonsignificant) trend for greater overestimation of past-week physical activity for higher BMI men among a sample of 24.[11] One study of 115 men and women living in a research laboratory for 2 days used room calorimetry as the criterion and found significant overestimation of moderate and vigorous physical activity as a function of the levels of body fat.[12] Thus, the obesity-overestimation effect appears fairly robust for recalls of total activity using methods other than accelerometry. The current study establishes the same overestimates using accelerometry among a community sample with less restrictive eligibility standards. The results suggest that asking about minimum 8-minute bouts does not provide a sufficiently salient prompt to make the overestimation bias disappear; the bias is just as prominent in the current study of bout recalls as it is in past studies of total activity recalls.

In future studies, accelerometry feedback might be useful in training volunteers who want to learn when their activity becomes moderate in intensity. As technology advances, accelerometry feedback might be more immediate, allowing instantaneous feedback regarding the proper intensity goals for brisk walking. Publicity campaigns might also highlight how a faster walk or longer walks to transit or other community destinations can convert a light activity into a healthier activity of moderate intensity. This information and accelerometry training might be particularly important for obese individuals who need to achieve moderate-intensity activity but are more inaccurate in recalling moderate-intensity bouts.

An important caveat is that we are assuming that accelerometers provide accurate measures of moderate-intensity bouts. Some researchers[11,29] suggest that obese individuals might incur a higher energy cost than indicated by the accelerometer. If so, obese individuals should not use current accelerometer 3.0 MET standards for feedback. Similarly, we assessed bouts in line with the CDC-ACSM standard of 8- to 10-minute minimums. Some research suggests that even shorter bouts might provide health benefits,[30] so our findings might underestimate bouts with demonstrated health benefits.

Future research could overcome some of the limitations in this research. For example, accelerometers could be combined with Global Positioning System (GPS) units to verify the accuracy of the recalled locations and destinations. When participants recalled that their moderate bouts had a rail stop destination, their self-reported destination could be validated with GPS. In addition, this study involved a community sample in 1 neighborhood, so future studies with varied participant characteristics are needed to establish generalizability. Finally, we assessed residents within a half mile direct distance of the new stop and measured distances to stops in direct measures; some researchers have uncovered useful results by relying on direct distances,[16] whereas others advocate the utility of considering street network distances or a variety of impedances within those distances.[15] We note that our study area does have a gridded street pattern, so direct and street-network distances might not be very different. Future research is also needed to understand the reason for overestimates among obese individuals. Walking has been shown to be experienced as more effortful for obese than nonobese individuals,[29] perhaps leading them to mistakenly recall light activity bouts as moderate energy-expenditure bouts.

In sum, accelerometry feedback can be used to address new questions. We identified questions about obese and nonobese individuals for which accelerometry validation of self-report was particularly useful. We also identified a particular type of activity—walks to transit—in which accelerometry feedback allows participants to get a memory prompt that can help identify moderate bouts of interest. As researchers focus more on the natural ecology of walkability and active living,[31] this type of prompting might prove to be quite useful. The combination of accelerometry data with self-reports provides information about the duration, intensity, and community destination of moderate-intensity walking bouts.

Acknowledgments

This research was supported in part by the University of Utah's Institute of Public and International Affairs, the University Research Committee, a University of Utah Instrumentation Grant (James Hannon, PI), and the Research Experience for Undergraduates (REU) Program, the National Science Foundation, under grant ATM 0215768. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the view of the NSF. We appreciate assistance from Stephanie Nalbone, Jonathan Gallimore, Melissa Napier, Elisa Hamblin, Chad Killpack, Bekah Larson, Edward Cusack, and Jared Campbell. We thank James Hannon and the anonymous reviewers for helpful comments on an earlier draft.

References

1. US Department of Health and Human Services, Centers for Disease Control and Prevention. *Physical Activity and Health: A Report of the Surgeon General*. Atlanta, GA: US Dept of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion; 1996.
2. Pate RR, Pratt M, Blair SN, et al. Physical activity and public health: a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA*. 1995;273:402–407.
3. Murtagh EM, Boreham CAG, Murphy MH. Speed and exercise intensity of recreational walkers. *Prev Med*. 2002;35(4):397–400.
4. Parise C, Sternfeld B, Samuels S, Tager IB. Brisk walking speed in older adults who walk for exercise. *J Am Geriatr Soc*. 2004;52(3):411–416.
5. Besser LM, Dannenberg AL. Walking to public transit: steps to help meet physical activity recommendations. *Am J Prev Med*. 2005;29(4):273–280.
6. Wener RE, Evans GW. A morning stroll: levels of physical activity in car and mass transit commuting. *Environ Behav*. 2007;39(1):62–74.
7. Ainsworth BE. The Compendium of Physical Activities Tracking Guide. Prevention Research Center, Norman J. Arnold School of Public Health, University of South Carolina; 2002. http://prevention.sph.sc.edu/tools/docs/documents_compendium.pdf. Accessed November 7, 2007.
8. Badland HM, Schofield GM. The built environment and transport-related physical activity: what we do and do not know. *J Phys Act Health*. 2005;2:435–444.
9. Sallis JF, Saelens BE. Assessment of physical activity by self-report: status, limitations, and future directions. *Res Q Exerc Sport*. 2000;71(2):S1–S14.
10. Durante R, Ainsworth BE. The recall of physical activity: using a cognitive model of the question-answering process. *Med Sci Sports Exerc*. 1996;28(10):1282–1291.
11. Irwin ML, Ainsworth BE, Conway JM. Estimation of energy expenditure from physical activity measures: determinants of accuracy. *Obes Res*. 2001;9:517–525.
12. Buchowski MS, Townsend KM, Chen KY, Acra SA, Sun M. Energy expenditure determined by self-reported physical activity is related to body fatness. *Med Sci Sports Exerc*. 1999;7:23–33.

13. Mahabir S, Baer DJ, Giffen C, et al. Comparison of energy expenditure estimates from 4 physical activity questionnaires with doubly labeled water estimates in postmenopausal women. *Am J Clin Nutr.* 2006;84(1):230–236.
14. Walsh MC, Hunter GR, Sirikul B, Gower BA. Comparison of self-reported with objectively assessed energy expenditure in black and white women before and after weight loss. *Am J Clin Nutr.* 2004;79:1013–1019.
15. Schlossberg M, Brown N. Comparing transit-oriented development sites by walkability indicators. *Transportation Res Rec.* 2004;1887:34–42.
16. Cervero R, Duncan M. *Residential Self-Selection and Rail Commuting: A Nested Logit Analysis.* Berkeley, CA: University of California Transportation Center; 2002.
17. Brown BB, Werner CM. A new rail stop: tracking moderate physical activity bouts and ridership. *Am J Prev Med.* 2007;33(4):306–309.
18. Welk GJ, Schaben JA, Morrow JR Jr. Reliability of accelerometry-based activity monitors: a generalizability study. *Med Sci Sports Exerc.* 2004;36(9):1637–1645.
19. Brown BB, Werner CM, Kim N. Personal and contextual factors supporting the switch to transit use: evaluating a natural transit intervention. *Analyses Soc Issues Public Policy (ASAP).* 2003;3(1):139–160.
20. Freedson PS, Melanson E, Sirard J. Calibration of the Computer Science and Applications, Inc. accelerometer. *Med Sci Sports Exerc.* 1998;30(5):777–781.
21. Troped PJ, Saunders RP, Pate RR, Reininger B, Ureda JR, Thompson SJ. Associations between self-reported and objective physical environmental factors and use of a community rail-trail. *Prev Med.* 2001;32(2):191–200.
22. Cohen DA, Ashwood JS, Scott MM, et al. Public parks and physical activity among adolescent girls. *Pediatrics.* 2006;118(5):E1381–E1389.
23. Cooper AR, Page AS, Foster LJ, Qahwaji D. Commuting to school: are children who walk more physically active? *Am J Prev Med.* 2003;25(4):273–276.
24. Cutt H, Giles-Corti B, Knuiman M, Burke V. Dog ownership, health and physical activity: a critical review of the literature. *Health Place.* 2007;13(1):261–272.
25. Owen N, Humpel N, Leslie E, Bauman A, Sallis JF. Understanding environmental influences on walking: review and research agenda. *Am J Prev Med.* 2004;27(1):67–76.
26. Simpson ME, Serdula M, Galuska DA, et al. Walking trends among US adults: the Behavioral Risk Factor Surveillance System, 1987–2000. *Am J Prev Med.* 2003;25(2):95–100.
27. Schutz Y, Weinsier S, Terrier P, Durrer D. A new accelerometric method to assess the daily walking practice. *Int J Obes.* 2002;26(1):111–118.
28. Pintar JA, Robertson RJ, Kriska AM, Nagle E, Goss FL. The influence of fitness and body weight on preferred exercise intensity. *Med Sci Sports Exerc.* 2006;38(5):981–988.
29. Mattsson E, Larsson UE, Rössner S. Is walking for exercise too exhausting for obese women? *Int J Obes Relat Metab Disord.* 1997;21(5):380–386.
30. Macfarlane DJ, Taylor LH, Cuddihy TF. Very short intermittent vs continuous bouts of activity in sedentary adults. *Prev Med.* 2006;43(4):332–336.
31. Brown BB, Werner CW, Amburgey J, Szalay C. Walkable route perceptions and physical features: converging evidence for en route walking experiences. *Environ Behav.* 2007;39(1):34–61.